# Enhanced Water Quality Monitoring and Modeling Program for the A.R.M. Loxahatchee National Wildlife Refuge
## Quarterly Update Report – October 2009

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Overview

This update is a summary of activities since the previous status report of July 2009 on the implementation of the Refuge's Enhanced Water Quality Monitoring and Modeling Program. A project overview, and other detailed information about the program can be found at: http://sofia.usgs.gov/lox_monitor_model/. The primary objective of this overall program (Brandt et al. 2004) focuses on providing information for use in ecological management of the Refuge (e.g., USFWS 2007a, b).

The Refuge's monitoring component of this program also addresses one of the Consent Decree Principals recommendations (17 December 2003):

> ***B. Enhancing Monitoring of the Refuge***
> *Design and implement an enhanced monitoring program to improve spatial and temporal understanding of factors related to phosphorus dynamics.*

The Refuge's modeling component of this program also addresses several of the Consent Decree Principals recommendations (17 December 2003):

> ***C. Modeling of the Refuge***
> *1. Develop a water quality/hydraulic model for the Refuge with a phosphorus cycling component.*
> *2. Evaluate issues associated with phosphorus loads and transports within the L-40 and L-7 canals.*
> *3. Develop and track a simple phosphorus mass-balance model for the Refuge.*

Information Availability

Through collaboration with USGS, information from the Refuge's Enhanced Water Quality Monitoring and Modeling Program has been made available on the USGS' SOFIA web site at: http://sofia.usgs.gov/lox_monitor_model/.

Final data for monthly samples through May 2006 are publicly posted on DBHYDRO by the SFWMD at http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.main_page. Data for June 2006-September 2009 are posted on the Technical Oversight Committee's web site at https://my.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_era/pg_sfwmd_era_techovercommittee. This report includes information from samples collected through September 2009.

Water Quality Data Analyses Update

Primary efforts for this quarter involved exploring mechanisms to continue translating information from the program to aid in Refuge management decisions, and finalization of the 4th Annual Report in July (USFWS 2009).

Monitoring Update (July 2009 – September 2009)

Sampling of the enhanced water quality monitoring network (**Figure 1**) occurred at 37 stations in July, 33 stations in August, and 37 stations in September 2009 (**Table 1**).

Total phosphorus data available to date for October 2008 to September 2009 are presented in **Table 1**. Maps of stations where samples were collected for July 2009 through September 2009 are presented in **Figures 2-4**.

Conductivity sonde deployment information for October 2008 to September 2009 is presented in **Table 2**.

Modeling Update

During the quarter extending, the Refuge modeling team continued efforts to finalize model versions. Efforts also continued on documentation of model development, use, and appropriate application. Specifically, manuscripts detailing aspects of the modeling were drafted and are under review. One model application being investigated evaluates the sensitivity of the model predictions to using hourly rather than daily-average inflows from the STAs. Results of this investigation will determine the degree to which the use of daily-average flow might bias hydrologic and water quality model projections. Additionally, quantifying this sensitivity may help us understand whether extended daily pumping schedules might reduce canal water intrusion.

Next Steps

The next steps for this program include initial development of the 5th Annual Report and additional model development and application.

References

Brandt, L.A., Harwell, M., Waldon, M. (2004) Work Plan: Water Quality Monitoring and Modeling for the A.R.M. Loxahatchee National Wildlife Refuge: 2004-2006. Prepared for the A.R.M. Loxahatchee National Wildlife Refuge. April, 2004. 33 pp.

USFWS. (2007a) A.R.M. Loxahatchee National Wildlife Refuge - Enhanced Monitoring and Modeling Program – 2nd Annual Report – February 2007. LOXA06-008, U.S. Fish and Wildlife Service, Boynton Beach, FL. 183 pp.

USFWS. (2007b) A.R.M. Loxahatchee National Wildlife Refuge - Enhanced Water Quality Monitoring and Modeling Program – 3rd Annual Report – October 2007. LOXA07-005, U.S. Fish and Wildlife Service, Boynton Beach, FL. 116 pp.

USFWS. (2009) A.R.M. Loxahatchee National Wildlife Refuge - Enhanced Water Quality Monitoring and Modeling Program – 4th Annual Report – July 2009. LOXA09-007, U.S. Fish and Wildlife Service, Boynton Beach, FL. 106 pp.

**Table 1.** Total phosphorus data (ppb) available for October 2008 – September 2009 from the Enhanced Water Quality Monitoring Program for: (a) marsh, and (b) canal stations for the A.R.M. Loxahatchee National Wildlife Refuge. Graphical representation of station locations are shown in Figure 1.

a) Marsh stations

| Marsh Station | Oct-08 | Nov-08 | Dec-08 | Jan-09 | Feb-09 | Mar-09 | Apr-09 | May-09 | Jun-09 | Jul-09 | Aug-09 | Sep-09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOXA101 | 14 | 3 | 10 | 9 | 3 | - | - | - | 32 | 9 | 20 | 11 |
| LOXA102 | 15 | 3 | 28 | 10 | - | - | - | - | 9 | U | - | 9 |
| LOXA103 | 16 | 3 | 15 | 11 | - | - | - | - | 10 | U | 20 | 10 |
| LOXA105 | 17 | 11 | 10 | 9 | 3 | - | - | - | 28 | 6 | 23 | 19 |
| LOXA106 | 14 | 7 | 10 | - | - | - | - | - | 21 | U | 19 | 11 |
| LOXA107 | 10 | 7 | 4 | - | - | - | - | - | 13 | 12 | - | 17 |
| LOXA108 | 9 | 3 | 13 | - | - | - | - | - | 5 | 4 | - | 7 |
| LOXA109 | 13 | 7 | 7 | 9 | 3 | - | - | - | 12 | U | 15 | 8 |
| LOXA110 | 10 | 7 | 3 | 3 | - | - | - | - | 3 | 6 | 14 | 9 |
| LOXA111 | 10 | 3 | 6 | 6 | - | - | - | - | 4 | U | 14 | 7 |
| LOXA112 | 12 | 7 | 8 | 8 | 3 | - | - | - | 12 | U | 15 | 19 |
| LOXA113 | 7 | 7 | 5 | 3 | - | - | - | - | 5 | 6 | 14 | 11 |
| LOXA114 | 10 | 3 | 7 | 5 | 3 | - | - | - | 5 | U | 13 | 8 |
| LOXA117 | 24 | 9 | 10 | 8 | 3 | - | - | - | 31 | 13 | 24 | 12 |
| LOXA118 | 15 | 8 | 10 | 9 | 3 | U | - | - | 7 | 21 | 16 | 6 |
| LOXA119 | 10 | 3 | 6 | 9 | 3 | 4 | - | - | 8 | 4 | 15 | 5 |
| LOXA120 | 6 | 3 | 3 | 30 | 3 | 3 | 9 | - | 2 | U | 14 | 5 |
| LOXA122 | 15 | 6 | 7 | 62 | 3 | - | - | - | 22 | 15 | 26 | 9 |
| LOXA124 | 18 | 3 | 5 | 4 | 3 | 13 | - | - | 37 | 13 | 21 | 18 |
| LOXA126 | 11 | 3 | 4 | 12 | 3 | - | - | - | 15 | 12 | 18 | 12 |
| LOXA127 | 11 | 3 | 3 | - | - | - | - | - | 10 | 5 | 21 | 19 |
| LOXA128 | 7 | 3 | 3 | 3 | - | - | - | - | 2 | U | 33 | 7 |
| LOXA130 | 16 | 10 | 13 | 7 | 3 | - | - | - | 17 | 13 | 17 | 12 |
| LOXA131 | 7 | 3 | 8 | 7 | 3 | - | - | - | 5 | 9 | 17 | 4 |
| LOXA133 | 31 | 18 | 21 | - | - | - | - | - | 140 | 16 | - | 37 |
| LOXA134 | 15 | 8 | 12 | 11 | 3 | - | - | - | 29 | 7 | 20 | 16 |
| LOXA136 | 64 | 9 | 14 | 9 | 3 | - | - | - | 51 | 30 | 25 | 26 |
| LOXA137 | 17 | 3 | 10 | 16 | 3 | - | - | - | 27 | 8 | 21 | 14 |
| LOXA138 | 9 | 3 | 5 | 17 | - | - | - | - | 7 | 13 | 44 | 8 |
| LOXA139 | 12 | 3 | 11 | - | - | - | - | - | 14 | 5 | 13 | 9 |
| LOXA140 | 10 | 3 | 12 | 9 | - | - | - | - | 20 | 12 | 18 | 13 |
| LOXA141 | 12 | 6 | 6 | 8 | 3 | U | - | - | 12 | 5 | 22 | 10 |
| MAX | 64 | 18 | 28 | 62 | 3 | 13 | 9 | 0 | 140 | 30 | 44 | 37 |
| MIN | 6 | 3 | 3 | 3 | 3 | 3 | 9 | 0 | 2 | 4 | 13 | 4 |

U indicates that compound was analyzed, but the concentration was below the minimum detection limit.

**Table 1 cont.**

b) Canal stations

| Canal Station | Oct-08 | Nov-08 | Dec-08 | Jan-09 | Feb-09 | Mar-09 | Apr-09 | May-09 | Jun-09 | Jul-09 | Aug-09 | Sep-09 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOXA104 | 33 | 34 | 26 | 22 | 10 | 32 | 30 | 30 | 60 | 42 | 44 | 47 |
| LOXA115 | 33 | 23 | 12 | 20 | 4 | 25 | 19 | 11 | 26 | 64 | 41 | 43 |
| LOXA129 | 42 | 21 | 19 | 11 | 21 | 40 | 44 | 34 | 130 | 33 | 80 | 42 |
| LOXA132 | 48 | 24 | 22 | 12 | 24 | 37 | 37 | 58 | 130 | 30 | 77 | 57 |
| LOXA135 | 49 | 13 | 22 | 14 | 21 | 42 | 33 | 45 | 130 | 61 | 61 | 43 |
| | | | | | | | | | | | | |
| MAX | 49 | 34 | 26 | 22 | 24 | 42 | 44 | 58 | 130 | 64 | 80 | 57 |
| MIN | 33 | 13 | 12 | 11 | 4 | 25 | 19 | 11 | 26 | 30 | 41 | 42 |

U indicates that compound was analyzed, but the concentration was below the minimum detection limit.

**Table 2.** October 2008 – September 2009 conductivity sonde deployment information, separated by transect, for the A.R.M. Loxahatchee National Wildlife Refuge. X = data collected from sonde deployment during that month. Graphical representation of station locations are shown in Figure 1.

| | 2008 | | | 2009 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site ID | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| LOXA104 | X | X | X | X | X | X | X | X | X | X | X | X |
| LOXA105 | | X | | X | | X | | X | | X | | X |
| LOXA106 | | X | | X | | X | | X | | X | | X |
| LOXA107 | | X | | X | | X | | X | | X | | X |
| LOXA108 | | X | | X | | X | | X | | X | | X |
| LOXA111 | X | | X | | X | | X | | X | | X | |
| LOXA112 | X | | X | | X | | X | | X | | X | |
| LOXA113 | X | | X | | X | | X | | X | | X | |
| LOXA114 | X | | X | | X | | X | | X | | X | |
| LOXA115 | X | X | X | X | X | X | X | X | X | X | X | X |
| LOXA116 | | X | X | | X | X | | X | | X | | X |
| LOXA117 | | X | X | | X | X | | X | | X | | X |
| LOXA118 | | X | X | | X | X | | X | | X | | X |
| LOXA119 | | X | X | | X | X | | X | | X | | X |
| LOXA120 | | X | X | | X | X | | X | | X | | X |
| LOXA126 | X | | X | | X | | X | | X | | X | |
| LOXA127 | X | | X | | X | | X | | X | | X | |
| LOXA128 | X | | X | | X | | X | | X | | X | |
| LOXA129 | X | X | X | X | X | X | X | X | X | X | X | X |
| LOXA130 | | X | | X | | X | | X | | X | | X |
| LOXA131 | | X | | X | | X | | X | | X | | X |
| LOXA132 | X | X | X | X | X | X | X | X | X | X | X | X |
| LOXA133 | | X | | X | | X | | X | | X | | X |
| LOXA135 | X | X | X | X | X | X | X | X | X | X | X | X |
| LOXA136 | | X | | X | | X | | X | | X | | X |
| LOXA137 | | X | | X | | X | | X | | X | | X |
| LOXA138 | | X | | X | | X | | X | | X | | X |
| LOXA139 | | X | | X | | X | | X | | X | | X |
| LOXA142 | | | X | X | X | X | | X | | X | X | |
| LOXA143 | X | | X | | X | | X | | X | | X | |
| LOXA144 | X | | X | | X | | X | | X | | X | |
| LOXA145 | X | | X | | X | | X | | X | | X | |
| LOXA146 | X | | X | | X | | X | | X | | X | |
| LOXA147 | | X | X | X | X | X | X | | X | X | | X |
| LOXA148 | X | | X | | X | | X | | X | | X | |
| LOXA149 | X | | X | | X | | X | | X | | X | |
| LOXA150 | X | | X | | X | | X | | X | | X | |
| LOXA151 | X | | X | X | X | X | X | X | X | X | X | X |
| LOXA152 | | X | X | X | X | X | X | X | X | X | X | X |
| LOXA153 | X | | X | X | X | X | X | X | X | X | X | X |
| I-8C | X | X | | X | X | | X | X | X | X | | X |
| LOX04 | | X | | X | | X | | X | | X | | X |
| LOX06 | X | | X | | X | | X | | X | | X | |
| LOX07 | X | | X | | X | | X | | X | | X | |
| LOX08 | X | | X | | X | | X | | X | | X | |
| LOX09 | X | | X | | X | | X | | X | | X | |
| LOX10 | X | | X | | X | | X | | X | | X | |
| LOX15 | X | | X | | X | | X | | X | | X | |

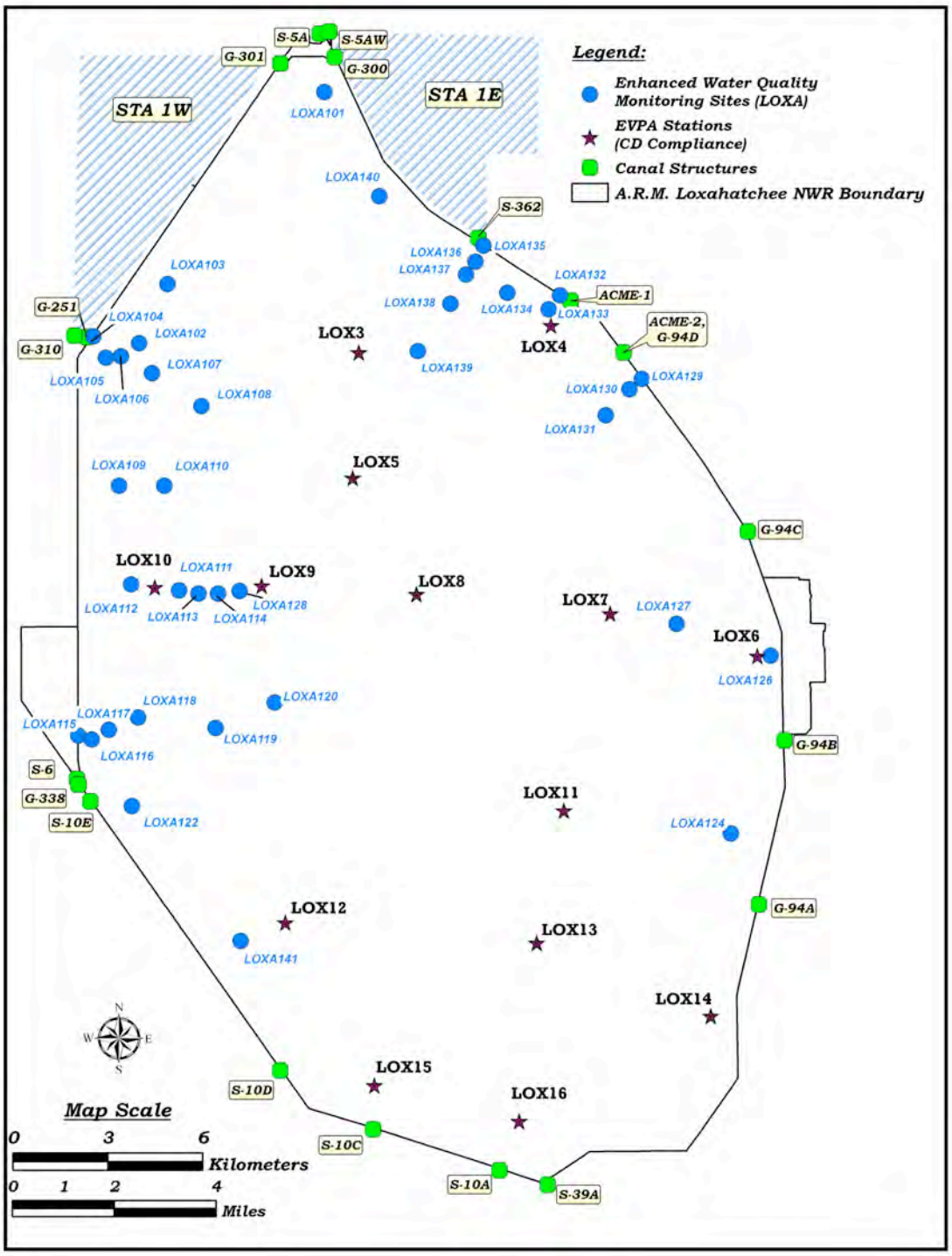


**Figure 1.** Location of Enhanced Water Quality Monitoring network stations (LOXA###), in relation to Consent Decree compliance stations (LOX##), for the A.R.M. Loxahatchee National Wildlife Refuge.

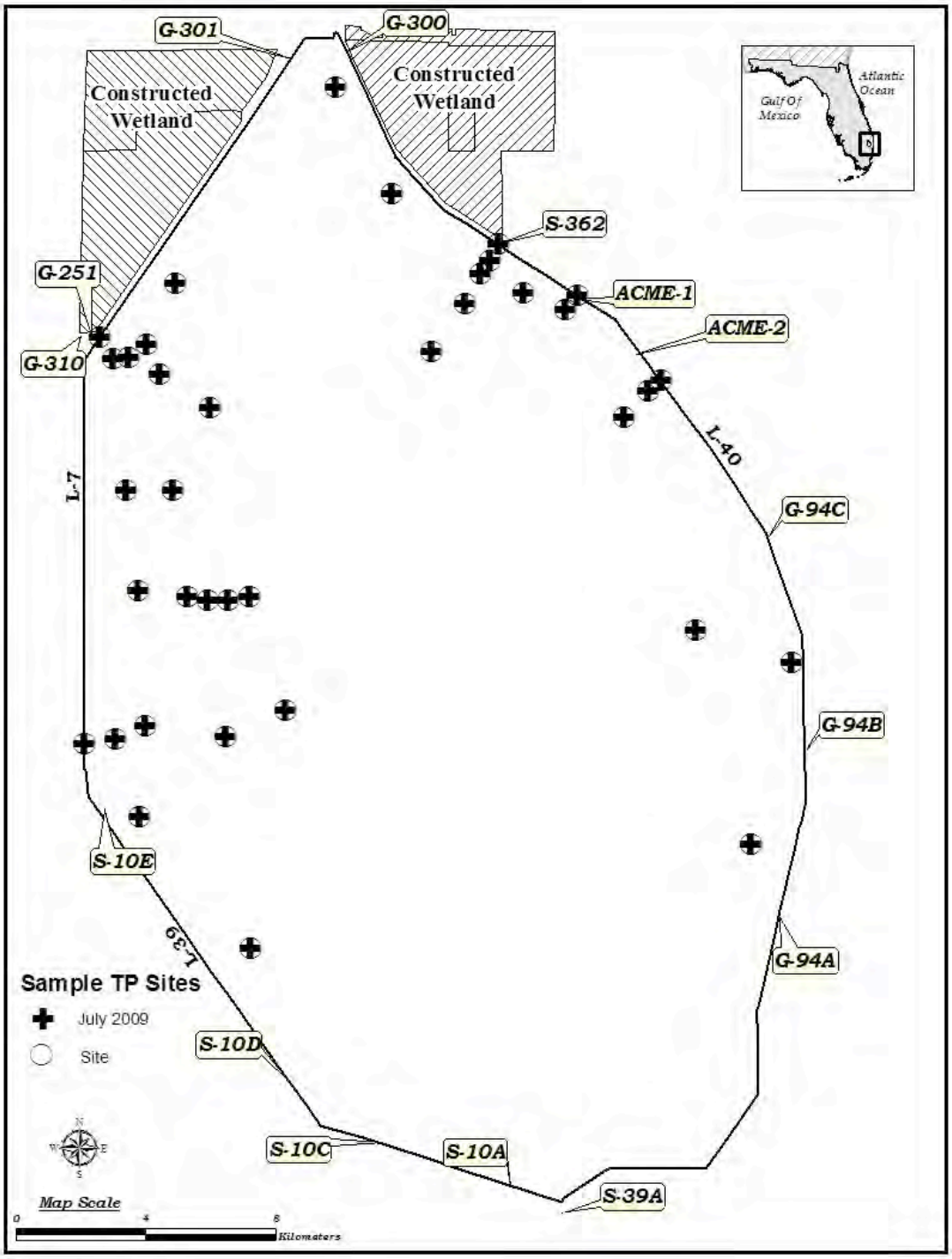


**Figure 2.** July 2009 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.

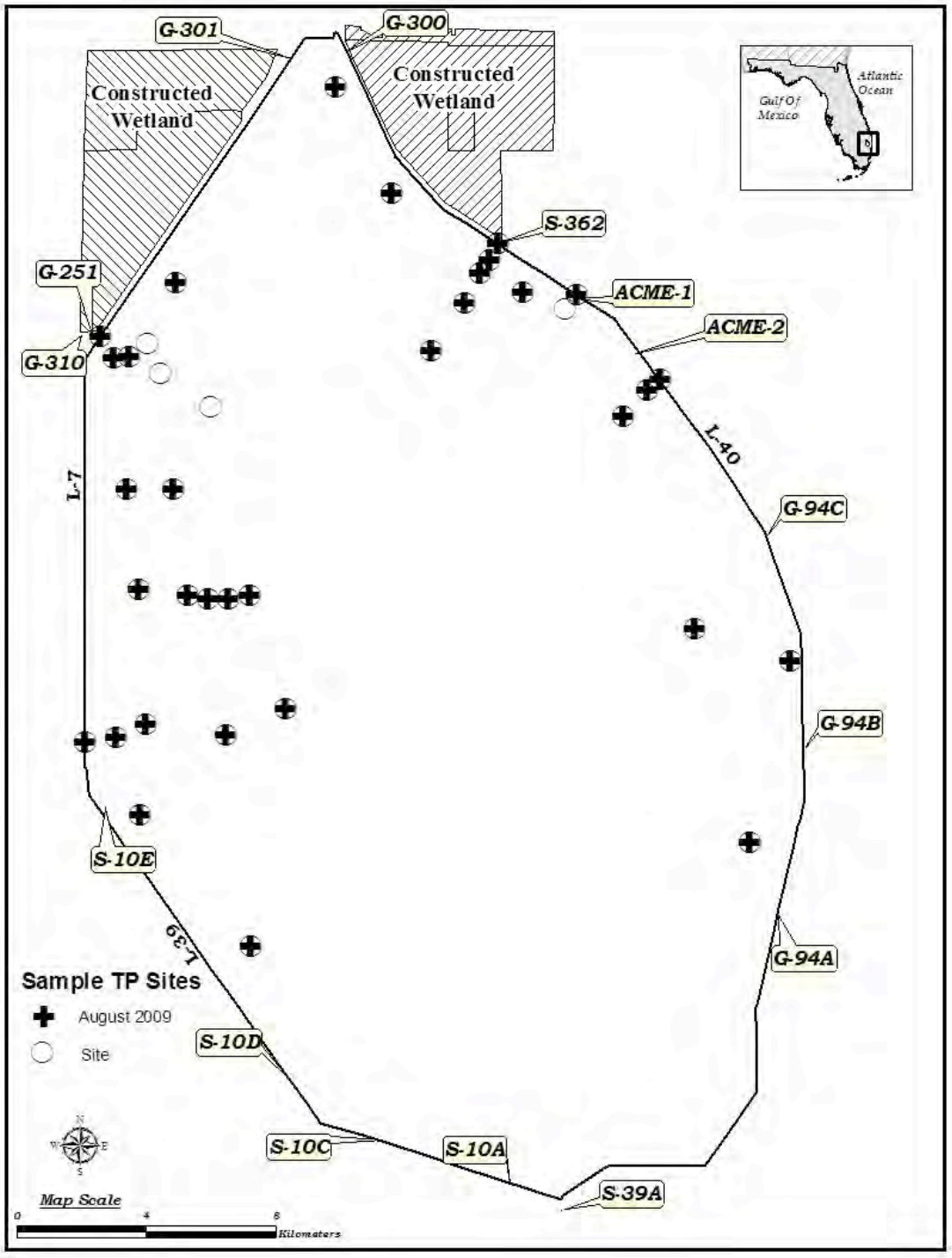


**Figure 3.** August 2009 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.

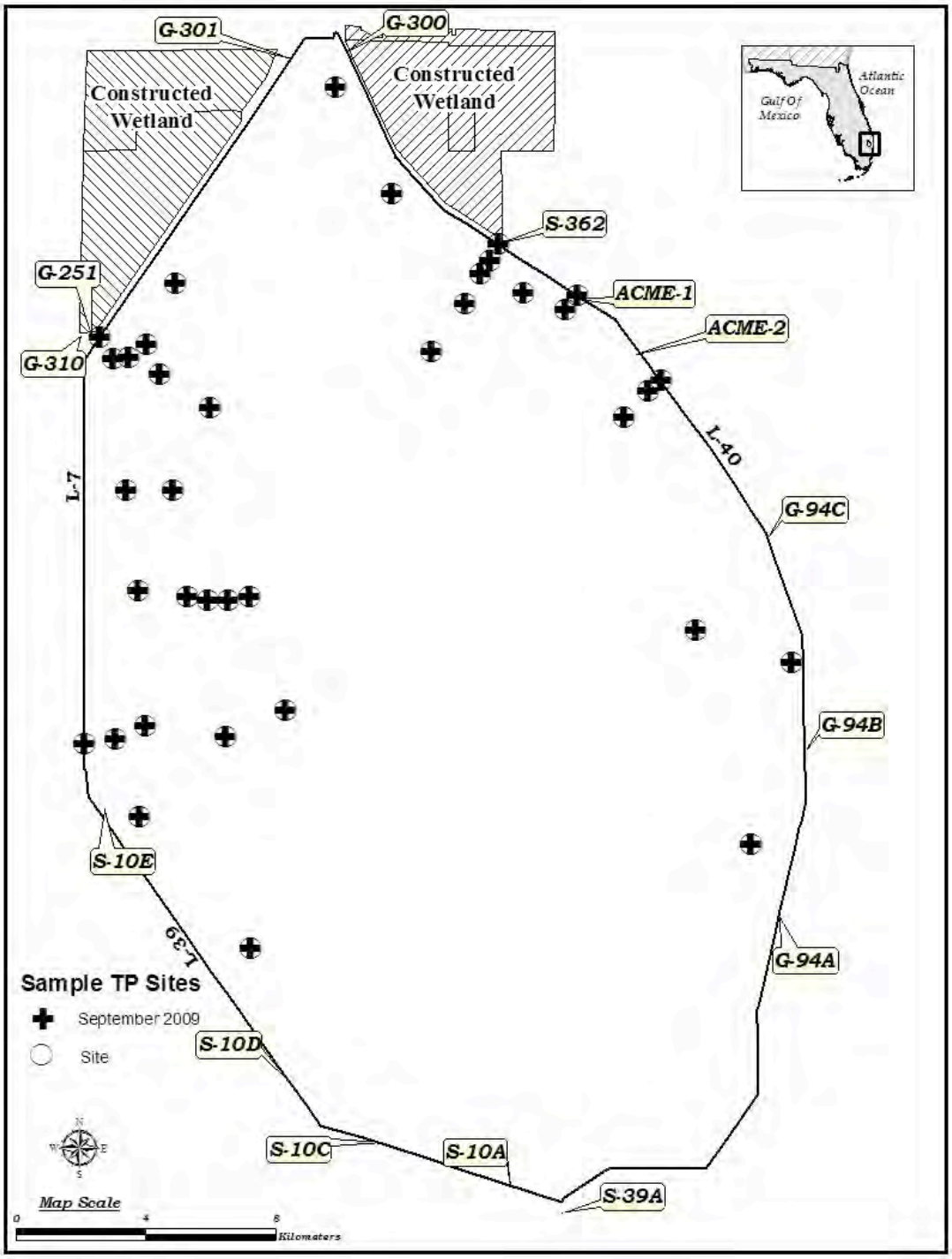


**Figure 4.** September 2009 map of total phosphorus sample collections from the Enhanced Water Quality Monitoring and the EVPA stations in the A.R.M. Loxahatchee National Wildlife Refuge. A primary reason that a station is not sampled is that it has less than 10 cm of clear water column representative of that area.